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Abstract

Educators in many disciplines recognize interdisciplinary teaching as effective for student learning. This article provides a model for developing an interdisciplinary literacy and science study with states of water as the core scientific study with corresponding literacy strategies. Authors have included suggestions for children's literature as well as science experiences to use with this study. This water model provides teachers a base for developing studies that integrate their literacy and science curricula.

Elementary teachers in the United States face heavy pressure for their students to perform well on state reading and writing tests (Akerson, 2001) and "...No Child Left Behind Act of 2001 (NCLB) is a major force in the day-to-day functions of America's public schools" (Settlage, 2004, p. 88). Consequently teachers often slight or ignore the science curriculum. Tilgner (1990) suggests that many teachers already eliminate science instruction when they need additional time during the school day "because it is their least favorite subject to teach" (p. 428). Without some changes, America's graduates may be in similar crises for scientific knowledge as they were in the 1960s. It's also true that some science teachers hesitate to include literacy because of their commitment to hands-on science teaching (Pappas, 2006). Since both curricular areas are vital for students, educators often turn to interdisciplinary teaching for scientific, reading, writing, and oral language experiences.

Supporting teachers is particularly important in light of study results that indicate how little actual science teaching occurs in elementary classrooms. Students may participate in science only once or twice a week spending as little as 18 minutes per day in science class (Gerlovich, Downs, & Magrane, 1981). Tilgner's (1990) work indicates that many teachers feel incapable of incorporating science in the classroom and that "teachers' negative attitudes and feelings of inadequacy" (p. 428) impact the quality of science instruction, often in a negative way. Current anecdotal evidence indicates that the picture has not changed noticeably in the 21st century.

The National Science Education Standards (NSES) (National Research Council, 1996) and Project 2061 (American Association for the Advancement of Science, 1990) documents call for stronger science teaching and, in particular, science literacy – not as an afterthought, but as a vital part of students' life skills. Pappas (2006) emphasizes the need for students to develop understanding of "the language that scientists use as they read, write, and talk" (p. 226). How does scientific literacy compete with other literacies such as reading and math literacies? In fact, the answer is not competition but cooperation. The answer also lies with teachers abandoning their heavy reliance on narrative texts for reading and writing while incorporating more informational texts.

Cross curricular or interdisciplinary teaching is not a new strategy for addressing the need to teach all curricular areas. In a 1996 joint position statement, the National Council of Teachers of English, International Reading Association, National Council of Teachers of Mathematics, Speech Communication Association, and Council for Elementary Science International asserted a child's school day should not be divided by content areas since that does not reflect life in our society (National Council of Teachers of English, International Reading Association, National Council of Teachers of Mathematics, Speech Communication Association & Council for Elementary Science International, 1996). The language arts, including reading and writing as well as oral communication skills, will enhance students' science experiences. However, all teachers should recognize that while tools of language arts can be used to support science instruction, and science can be used to provide a purpose for meaningful reading, writing, and discussion, "effective language arts instruction cannot substitute for hands-on science instruction, and effective science instruction cannot substitute for achieving general literacy skills" (Akerson & Flanigan, 2000, p. 359). Traditional textbooks do not provide adequate reading and writing in science texts nor sound science experiences in reading and writing textbooks. Thus, teachers benefit from models that support them in developing interdisciplinary curricular experiences which incorporate science experiences and children's literature. Duke's (2000) research indicates that students are reading very little informational text at lower grades, a time for building understanding of texts. Yet trade books do increase the opportunities for students to be involved with science concepts as well as provide opportunities for learning reading strategies for informational text (Madrazo, 1997; Tunnell & Jacobs, 1989). In fact, the use of nonfiction texts may increase the engagement of students (Hapgood & Palincsar, 2006) especially boys (Brassell, 2006) and even reluctant readers (Collard, 2003).

Making the Connections

Arguing that instruction packages that focus on a theme often neglect experiences that truly teach science concepts, Dickinson and Young (1998) propose interdisciplinary instruction as the most legitimate strategy for developing students' science and language arts literacies. Weaving together skills from both disciplines, teachers are able to maximize available instruction time (Rogers & Abell, 2007). Teaching with a theme that truly invites interdisciplinary learning presents challenges (Barton & Smith, 2000; Dickinson & Young, 1998; Shanahan, Robinson, & Schneider, 1995). Consequently, more models that support interdisciplinary strategies are important for educators.

Since children need to learn to think scientifically and learning is mediated through language (Maguire & Wolf, 1993), Stefanich (1992) suggests that integration across curricular areas is actually necessary for the successful teaching of science concepts. Children often link information in ways unlike their parents or teachers, so it is important to remember that "learning is seeing connections" (Peetoom, 1993, p. 7). Children will begin to make the link from where they are – not from where we as adults are. Huber and Walker (1996) describe how students working with magnets prior to reading about the magnets and their properties will help the children understand the scientific reading material. This permits the students to make their own connections. While Dickinson & Young (1998) elucidate similarities between language arts and science literacy, they also recognize that connections between the disciplines should be "logical, natural, and appropriate" while teachers "include experiences that will help students meet goals and objectives of both disciplines" (p. 337). Both science and language arts instructional strategies are included in the model described here for teaching students literacy strategies for comprehension

(NCTE/IRA Standard 3, International Reading Association & National Council of Teachers of English, 1996), inquiry methods using scientific methods as well as textual references (NSES Content Standard A) and physical science concepts through a study of water (NSES Content Standard B, National Research Council, 1996).

Wonders of Water as Model

Selecting the Study Focus

The first step for any interdisciplinary teaching is choosing the conceptual focus. Since literacy strategies are necessary for engagement with any text, science teaching can come first. Teachers need to consider the local and state science standards as well as student age and potential involvement with the experiences. To ensure maximum learning potential, student interest must be an important consideration.

Picarello (2000) notes "children's natural curiosity—was the most natural way to enhance language" (p. 47). Science experiences can provide an opportunity to develop literacy in reading, writing and communication. The study of water provides a viable connection to children's natural curiosity and easy access to materials as well as a connection to concept learning. Water's states are fairly easily demonstrated and experienced by students to learn about different states of matter and thus physical change. Water is also necessary for life forms, so it is pertinent for students to respect and understand. This model also takes teachers into the often-neglected area of physical science rather than life science.

Since water is such a broad topic, this model is appropriately focused on the more narrow concepts of the physical properties of water and the states of water as it evaporates, condenses, and freezes through liquid, gas, and solid states. Concepts such as these are common in curriculum standards for different grade levels and provide interesting experience opportunities. Books that support science concepts are available at different levels of reading.

Choosing Literature for the Study

Selecting appropriate literature for teaching and learning is the vital next step after choosing the science concepts, and Taberski (2001) recommends utilizing both fiction and nonfiction in the content areas. For example, teachers could develop students' critical reading skills by using the section about surface tension from *A Drop of Water* (Wick, 1997) and ideas from *The Bubble Factory* (de Paola, 1996). Students may start by comparing and contrasting these two types of books. Teachers can model critical reading strategies through discussion of how de Paola used his knowledge of surface tension to develop his story. The discussion should include strategies for recognizing fiction and nonfiction in books and reading more to verify any text's reliable presentation of information. It is important to note that the teachers should also address misrepresentations and anthropomorphism (Mayer, 1995). Anthropomorphism occurs when authors attribute human motivation, characteristics, and/or behavior to animals or objects in a book through text and illustrations. This can confuse young students. Although organisms other than humans do feed, take care of young and die, their lives are different. For example, children need to be able to recognize the difference between a fictional story about a squirrel named Ronda caring for her young and actual scientific information and photographs about the care and development of young squirrels.

Rice, Dudley, and Williams (2001) encourage the utilization of trade books in the teaching of science. However, they warn of the dangers of reinforcing or developing misconceptions through the use of deficient books. They stress the serious selection of children's literature and provide a checklist to help in the selection of accurate and quality texts. Big books, novels, storybooks, poetry, pop-up, inquiry, informational, and discovery and exploration books are all available to support science teaching (Lake, 1993). The Council for Elementary Science International (CESI) encourages the use of "a balance of picture books, novels, poetry, essays" to integrate curriculum (CESI, 2001, p. 8). Even science fiction can serve to link language arts and science when read with thought about the concepts presented (Atwater, 1995). Lake's (2000) perspective may be summed in her statement, "Science cannot occur in a vacuum. Concepts are better understood when presented in meaningful text and combined with hands-on experiences" (p. 88). Collard (2003) suggests that science trade books are particularly effective in modeling the traits of storytelling, organization, and voice. Although teachers may first be unsure of reading information books aloud (Donovan & Smolkin, 2001), doing so provides excellent opportunities to model scientific language and lead discussions about how wording differs according to the scientific concept being studied (Pappas, 2006).

A source of quality current literature is the annual list of outstanding children's science trade books for the preceding year (NSTA, 2007), published since 1973 in the March issues of *Science and Children*. A review panel composed of educators and experts representing the National Science Teacher Association and the Children's Book Council selects these books. Annotations provide useful information for classroom teachers and school media specialists.

When selecting books for the classroom, evaluations of texts need to include the aspects of science content and concepts, science skills, vocabulary, equipment depiction, balance among the sciences, genre variety, and special effects such as pop-ups and pull-tabs. A vital component of the learning process will be the teacher's familiarity with both children's books and science experiences. In order to provide optimum experiences for their students, teachers must first have knowledge of the books available and activities possible (Lake, 2000; Pringle & Lamme, 2005).

We've included four books that fit the criteria for the theme "Wonders of Water." Walter Wick's *A Drop of Water* (1997) demonstrates numerous concepts that are scientifically authentic and written in student-friendly form. Concepts such as surface tension, adhesion, water molecules in motion, evaporation, condensation, refraction, etc. are in this book. It is divided into sections, so each part of the book could accompany a lesson. To start this study, teachers can help build background knowledge (schema) by reading and discussing the sections "Water's Elastic Surface" and "When Water Flows Up" to set the stage for the adhesion and cohesion experiment. Wick's outstanding photographs provide the "Wow" to encourage students' curiosities for actually exploring to find out about water's properties. Children will want to peruse this book at their leisure, too.

E. C. Krupp's (2000) *The Rainbow and You*, illustrated by R. R. Krupp, has a blend of scientific information about water droplets and light refraction as well as rainbow myths of different historical origins. Using this book in science for further study of states of water could also lead to a study of myths in the reading curriculum. The tie is natural and lends itself to a short refresher study or a longer study of traditional literature with myths as one portion.

This is the Rain (2001), written by Lola M. Schaefer and illustrated by Jane Wattenberg, is a scientifically accurate book that is useful for young and/or struggling readers. The water cycle is the focus of this book written in the cumulative form of "The House that Jack Built." The repetition is rhythmic and easy, while the vocabulary expands students' repertoire of science terms. Starting with "This is the ocean, blue and vast, that holds the rainwater from the past," (n.p.) each section adds to that pattern. Following additions tell about warmed ocean water that forms vapor that forms clouds that fall as rain that collects in streams and rivers and eventually runs back into that "ocean, blue and vast" (n.p.). Students gain science concepts and vocabulary as well as reading vocabulary with this book.

For the mature readers, or for a selective teacher read-aloud, Sally Walker's (1992) *Water Up, Water Down: The Hydrologic Cycle* is packed with information, useful diagrams, and photographs. Students can use various reading strategies for finding information from headings and by skimming. This outstanding book would be helpful for teaching selective reading strategies that adults use when searching through informative texts for that piece of information they need – often hidden in a section somewhere in the middle of the book.

Although there are other books available, especially those that focus on the water cycle, these four provide examples of how teachers can select appropriate books with criteria and curriculum in mind. They also represent a range of reading levels – important to consider when selecting books. Books that are available in paperback can be purchased in sets of five or more so that groups of students can read and discuss them to support understanding which will ultimately help enhance comprehension (Galda & West, 1997; Gambrell & Almasi, 1996).

Textbooks do not offer the same range of manageable reading that children's books do (Watson, 1997). Lake (1993) points out that "Children engage in and learn best when activities and literature are matched to their stage of development" (p. 21). When students are reading during science time (and in other content areas), they are encountering texts that have purpose and reinforce the importance of understanding what they read (Daniels, Zemelman, and Bizar, 1999; Ivey, 2000; Madrazo, 1997). Tunnell and Jacobs (1989) comment on a study comparing student reading approaches. Students who interpreted reading as making meaning rather than a symbol-to-sound approach were better readers. Providing such meaning-making materials as appropriate science trade books will assist students in becoming more well-rounded, proficient readers.

The use of a K (What I know)-W (What do I want to learn?)-L (What I learned) chart as suggested by Ogle (1986) has demonstrated improved thinking as well as an increase in the enthusiastic reading of nonfiction literature. Using a KWL chart before reading the science books with water information would start students' organized thinking about their learning. This learning tool is helpful in both science and reading literacies and can easily carry over between experiences.

Science Learning Experiences

Interdisciplinary teaching involves connections, but still stresses teaching concepts and strategies important for the content disciplines. Thus, this "Wonders of Water" model includes some ideas specific for science learning and others specific for reading and writing growth. For example, after reading and discussing the two sections from *A Drop of Water* (Wick, 1997), students are ready to learn about adhesion and cohesion of water molecules by utilizing everyday materials (McCarty, 2000).

Have students first hold two sheets of dry paper together and note their ability to stick to each other. Next, have students wet both sheets of paper with water and hold them together. Ask students to thoughtfully respond to questions like: "How does this compare with the dry sheets?" and "What other materials might you test using this method?" With teacher assistance and this experience, students may begin to understand cohesion. Water (H_2O) is composed of 2 different atoms —hydrogen and oxygen. This combination makes water polar, meaning it has a negative and positive end (like a magnet). Paper also contains molecules that are polar so water molecules are attracted to the paper molecules. Sliding two wet sheets of paper apart is more difficult than peeling them because it requires breaking the attraction of more water molecules. Adhesion refers to the attraction of two different materials while cohesion refers to the attraction of a material to itself. Water molecules are cohesive. This experience directly relates to NSES Content Standard A as students employ simple equipment and tools to gather data and then use that data to construct reasonable explanations for the reaction(s) observed.

For introducing a second science experience, teachers can read with students or have students read *This is the Rain* (Schaefer, 2001) and discuss what they've learned about water and what happens when water gets warmer or colder. They could then speculate how this could be set up for observing in the classroom. The students are now ready to observe the evaporation-condensation experiment. The teacher heats water in a teapot on a hot plate, and after it starts to boil, places a saucepan full of ice water above the steam. S/he then places a cookie sheet under the saucepan. Water droplets will form on the saucepan and drip and "rain" on the cookie sheet. Again ask questions such as, "How is this classroom model like the water cycle?" Evaporation is affected by such factors as the temperature of the water, how much of the water is in contact with air, and the amount of wind. This water vapor condenses into droplets that form clouds. The combined droplets eventually become too heavy for air currents to hold up. This experience supports student learning for NSES Content Standard B. "Inquiry-based science experiences help students build prior knowledge and encounter concrete examples of vocabulary concepts" (Coskie, 2006, p. 62). Further science experience ideas can be found in Bosak's (2000) sourcebook of projects and activities.

As a follow-up, teacher or students could read *A Drop of Water* (Wick, 1997), focusing on the sections "Water Vapors," "Condensation," and "Evaporation Versus Condensation." It is natural to write about their experiences in order to aid memory, think through confusing or questionable developments, or simply record results.

Literacy Learning Experiences

Writing across the curriculum can be an effective link between the language arts and science (Atwater, 1995). "Writing can help students think through and develop scientific ideas. The union between science and language arts is natural and offers an opportunity for teachers to capitalize on their [own] strengths to provide students with better knowledge in each subject" (Akerson & Flanigan, 2000, p. 346). Dickinson and DiGisi (1998) found in a study of first-grade students that higher reading achievement scores resulted when students engaged in narrative and informational writing. Students' reading skills may be enhanced as a result of writing incorporated into science experiences.

Journals are often utilized when teaching science in the elementary classroom. El-Hindi (2003) notes that dialogue journals can provide an opportunity for students to reflect on scientific observations and considers journal writing crucial for developing scientific habits of mind. The author further asserts that "this, indeed, is the work of true scientists" (p. 537). Writing about science concepts assists internalization of science content. Teachers should also serve as role models demonstrating how to keep a journal and sharing both success and failure in the journal writing process (Freedman, 1999). Klein (2004) posits that significant thinking and learning occur during writing which also supports students as they develop their emergent writing skills. An additional benefit of student journals is that they provide documentation of student understandings, which can be useful assessment tools (Akerson & Young, 2005).

Russo (2000) reports how a teacher used graphic organizers to assist in the production of more complete journal entries for her young students' experiences at a local lake. Likewise, students who study water can use a semantic feature analysis to organize some of the information they've learned about changes in water. This is an opportunity to use text and experiences in a visible manner (Anders & Box, 1986; Pittelman, Heimlich, Berglund, & French, 1991). The semantic feature analysis in Figure 1 is an example of how one might look after the first science experience, or after reading the books named. In particular, students could use the book *This is* *the Rain* (Schaefer, 2001) to fill out all or part of the chart. Students put a positive (+) sign at the intersection of ideas that support each other and negative (–) where the ideas are not coordinated. Thus, there would be a plus in the box under clouds and in the same row as vapor. Waterfalls as a category was included to model for students that more than one water form is present in waterfalls. Science inquiry could then lead students and teacher to search for other settings where more than one form of water is present. "Inquiry science and literacy intersect when students use reading, writing, and oral language to address questions about science content...and to build their capacity to engage in scientific reasoning..." (Hapgood & Palincsar, 2006, p. 56).

Vapor							
Solid							
Liquid							
Condensation							
Evaporation							
Precipitation							

Figure 1. Water Changes

Students' representations of understanding need not be limited to writing. Creating diagrams by using both words and pictures to illustrate a science concept can demonstrate student understanding (Heller, 2006/2007). Even creating bumper stickers (1/2 of an 8 1/2 x 14 legal-size sheet of paper works well) to illustrate knowledge of issues such as water conservation provides opportunities for many students to succeed in demonstrating their knowledge. The production of comics can utilize "three thinking processes: idea synthesis, procedure writing, and communication" (Freedman, 1999, p. 105). The incorporation of multiple intelligences is also possible when students create skits, including writing and directing as well as props. Additional creative avenues for the expression of science concepts are stories, poetry, and songs (Freedman, 1999).

Prentice and Cousin (1993) note, "Personal stories illustrate how most students begin to internalize new ideas and make them their own. They are the starting point for true understanding and growth" (p. 55). After reading books with water themes, participating in science experiences that teach about water, and writing about what they know, students can use their imaginations to write a story about a character's experience with rain or water. Karen Hesse's (1999) picture book *Come On, Rain* is a poetic story of a little girl in an inner city waiting for rain in order to play in it. This book could be used as a writing invitation for students' own stories. Graham's (1994) *Splish Splash* contains concrete poetry about "Clouds," "Ocean," "Waterfall," and others that center around water. Although neither of these books is offered as a scientific information book, the story and poetry invite readers to recognize how the scientific concepts they're learning are part of their everyday lives making useful connections.

Conclusion

Pope (1993) proposes, "If students are asked simply to manipulate the teacher's and author's words or respond to them on objective tests, they may never construct a view; but if the students use their own words to think about their experiences, including experiences with words presented by others, understanding becomes a real possibility" (p. 160). When the experiences are used together, students are able to construct knowledge based on their own backgrounds and learn to value inquiry (Lake, 2000). Finally, "science books allow you to accomplish your reading and writing goals while filling in a major hole in our educational system" (Collard, 2003). Having a model to start with can help teachers find a way to use the literature and science experiences available to help their students learn.

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